(12) UK Patent Application (19) GB (11) 2 351 874 (13) A

(43) Date of A Publication 10.01.2001

(21) Application No 0011566.7

(22) Date of Filing 12.05.2000

(30) Priority Data
(31) 11131001 (32) 12.05.1999 (33) JP

(71) Applicant(s)
NEC Corporation
(Incorporated in Japan)
7-1 Shiba 5-chome, Minato-ku, Tokyo 108-01, Japan

(72) Inventor(s)
Yoshihiro Ono

(74) Agent and/or Address for Service
Mathys & Squire
100 Grays Inn Road, LONDON, WC1X 8AL,
United Kingdom

(51) INT CL⁷
H04L 29/10 // H04L 12/56 29/08

(52) UK CL (Edition S)
H4K KTKX
H4L LDGP

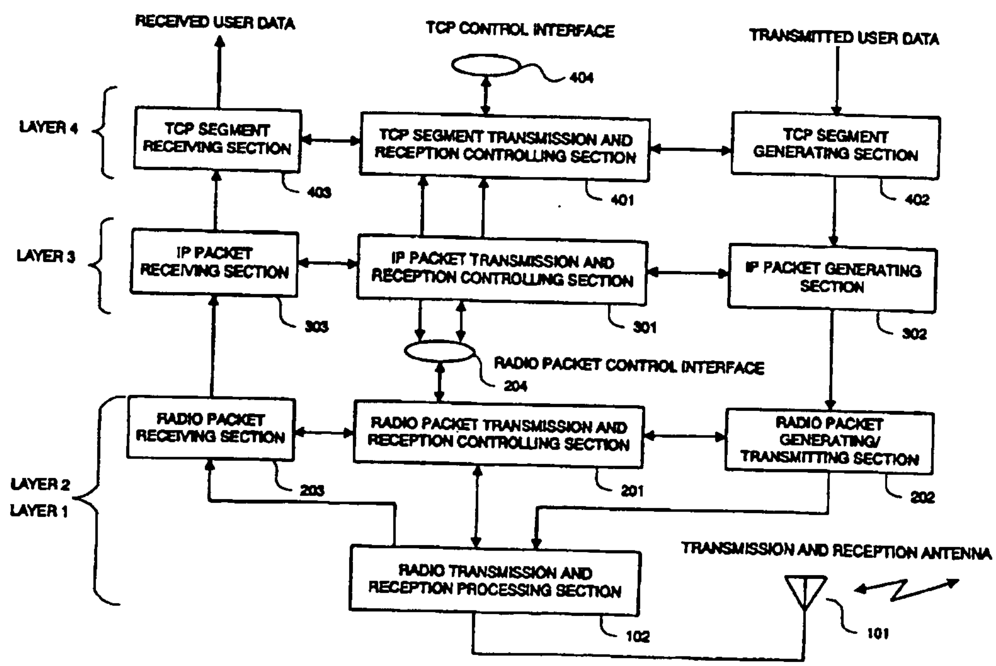
(56) Documents Cited
EP 0905950 A WO 98/45994 A2

(58) Field of Search
UK CL (Edition R) H4K KTK , H4L LDGP , H4P PPEC PPS
INT CL⁷ H04L 12/56 29/06 29/08 , H04Q 11/04
Online Databases: WPI, EPODOC, JAPIO

(54) Abstract Title
TCP segment size control in a packet data transfer apparatus

(57) An apparatus for transmitting and receiving packet data over a radio communication link has a protocol stack comprising TCP layer, IP layer and radio packet layer. Each layer has a transmitting, receiving and controlling section. A radio packet control interface 204 allows other layers to acquire radio channel information from the radio packet layer. Based on this information an IP layer controlling section dynamically controls a maximum packet size, and a TCP layer controlling section dynamically controls a maximum TCP segment size. Control of segment size avoids sending padding bits in the radio frame. The TCP layer controlling section can also issue a demand to the radio packet layer to set the radio link to a high speed link or a low speed link depending on the amount of user data predicted to result from the occurrence of a user data transfer demand.

FIG. 1



BEST AVAILABLE COPY

GB 2 351 874 A

FIG. 1

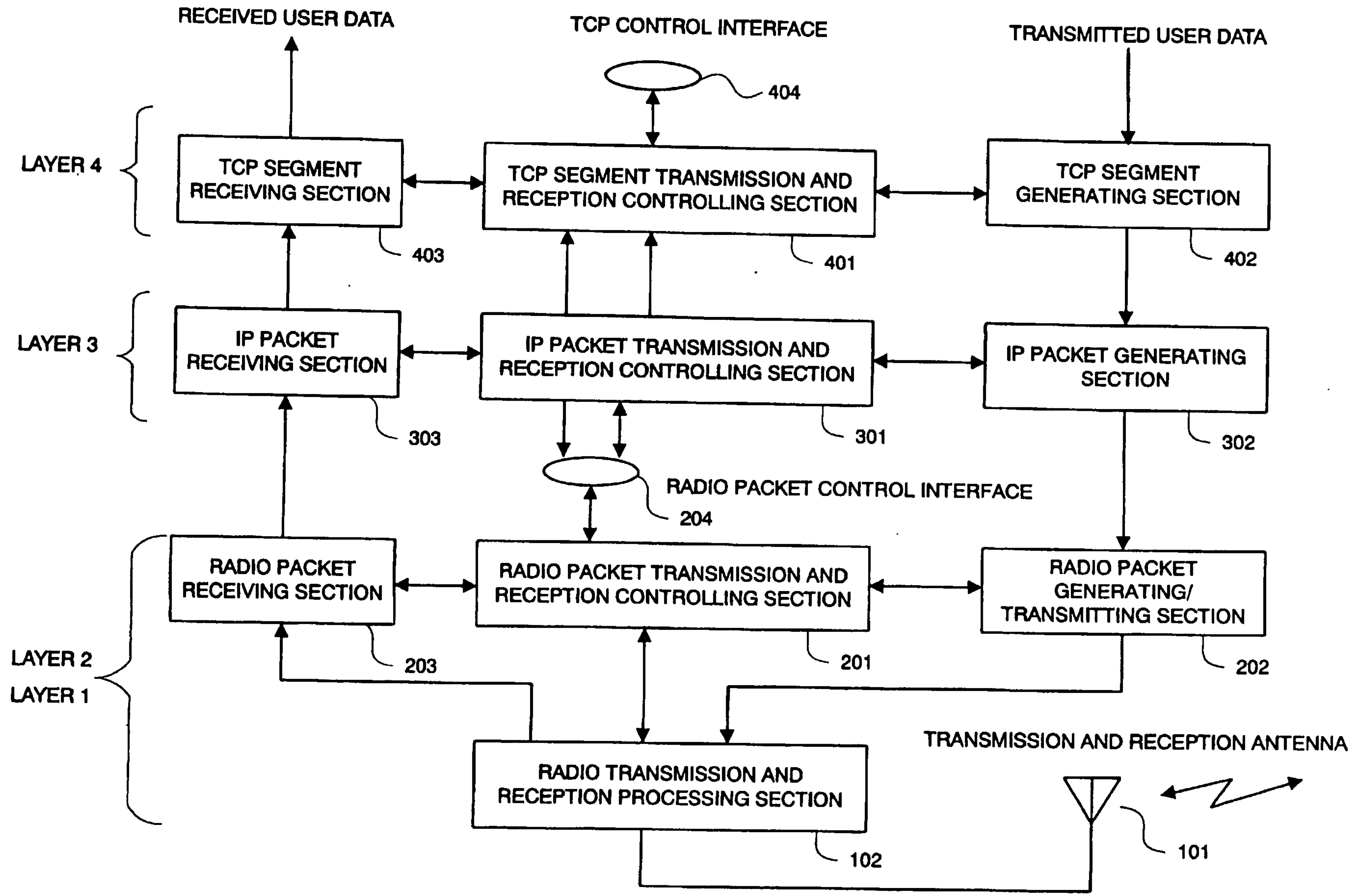

RECEIVED USER DATA
TCP CONTROL INTERFACE
TRANSMITTED USER DATA
404
LAYER 4
TCP SEGMENT RECEIVING SECTION
TCP SEGMENT TRANSMISSION AND RECEPTION CONTROLLING SECTION
TCP SEGMENT GENERATING SECTION
403
401
402
LAYER 3
IP PACKET RECEIVING SECTION
IP PACKET TRANSMISSION AND RECEPTION CONTROLLING SECTION
IP PACKET GENERATING SECTION
303
301
302
RADIO PACKET CONTROL INTERFACE
204
LAYER 2
LAYER 1
RADIO PACKET RECEIVING SECTION
RADIO PACKET TRANSMISSION AND RECEPTION CONTROLLING SECTION
RADIO PACKET GENERATING/ TRANSMITTING SECTION
203
201
202
TRANSMISSION AND RECEPTION ANTENNA
RADIO TRANSMISSION AND RECEPTION PROCESSING SECTION
102
101

FIG. 2

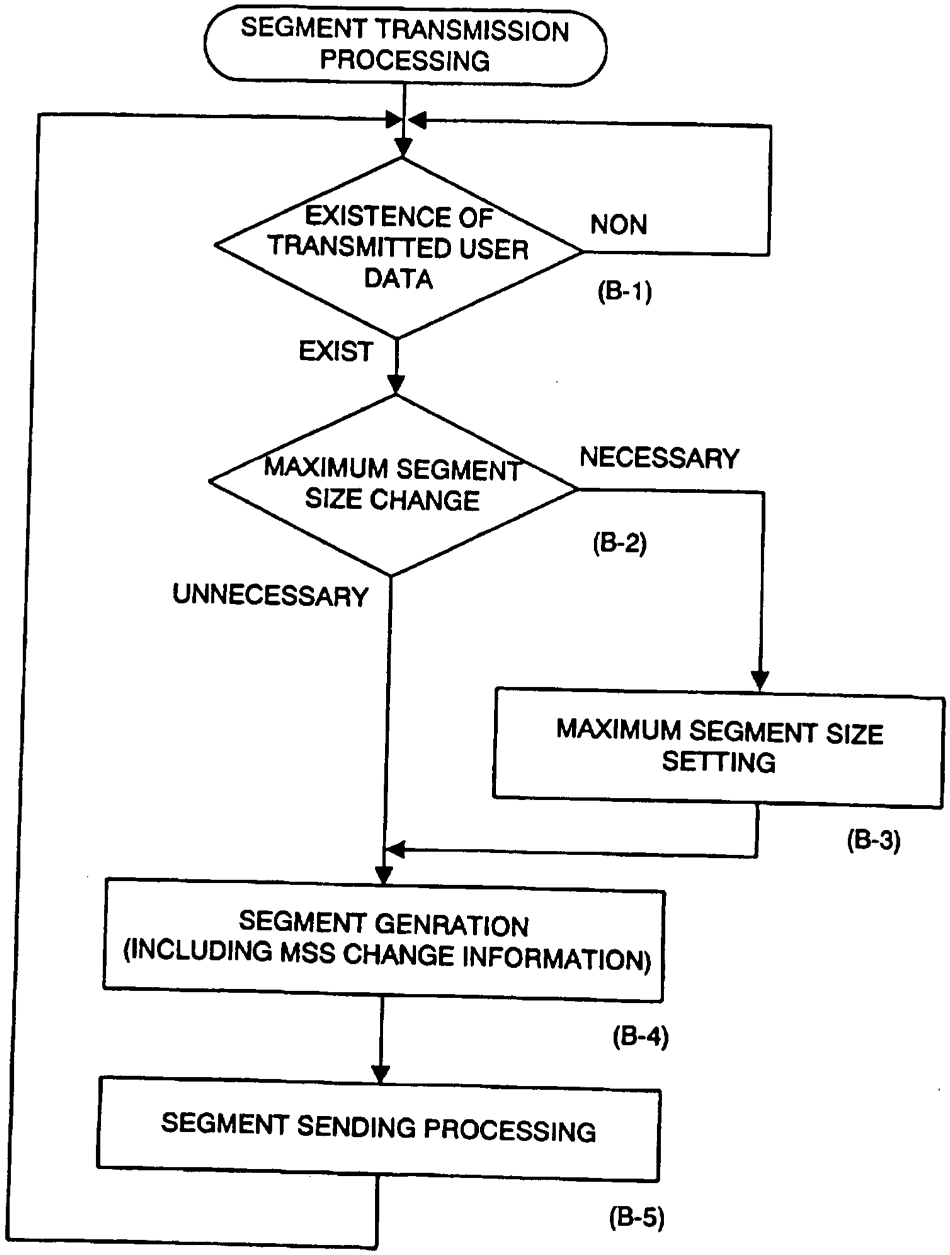

SEGMENT TRANSMISSION PROCESSING
EXISTENCE OF TRANSMITTED USER DATA
NON
(B-1)
EXIST
MAXIMUM SEGMENT SIZE CHANGE
NECESSARY
(B-2)
UNNECESSARY
MAXIMUM SEGMENT SIZE SETTING
(B-3)
SEGMENT GENRATION (INCLUDING MSS CHANGE INFORMATION)
(B-4)
SEGMENT SENDING PROCESSING
(B-5)

FIG. 3

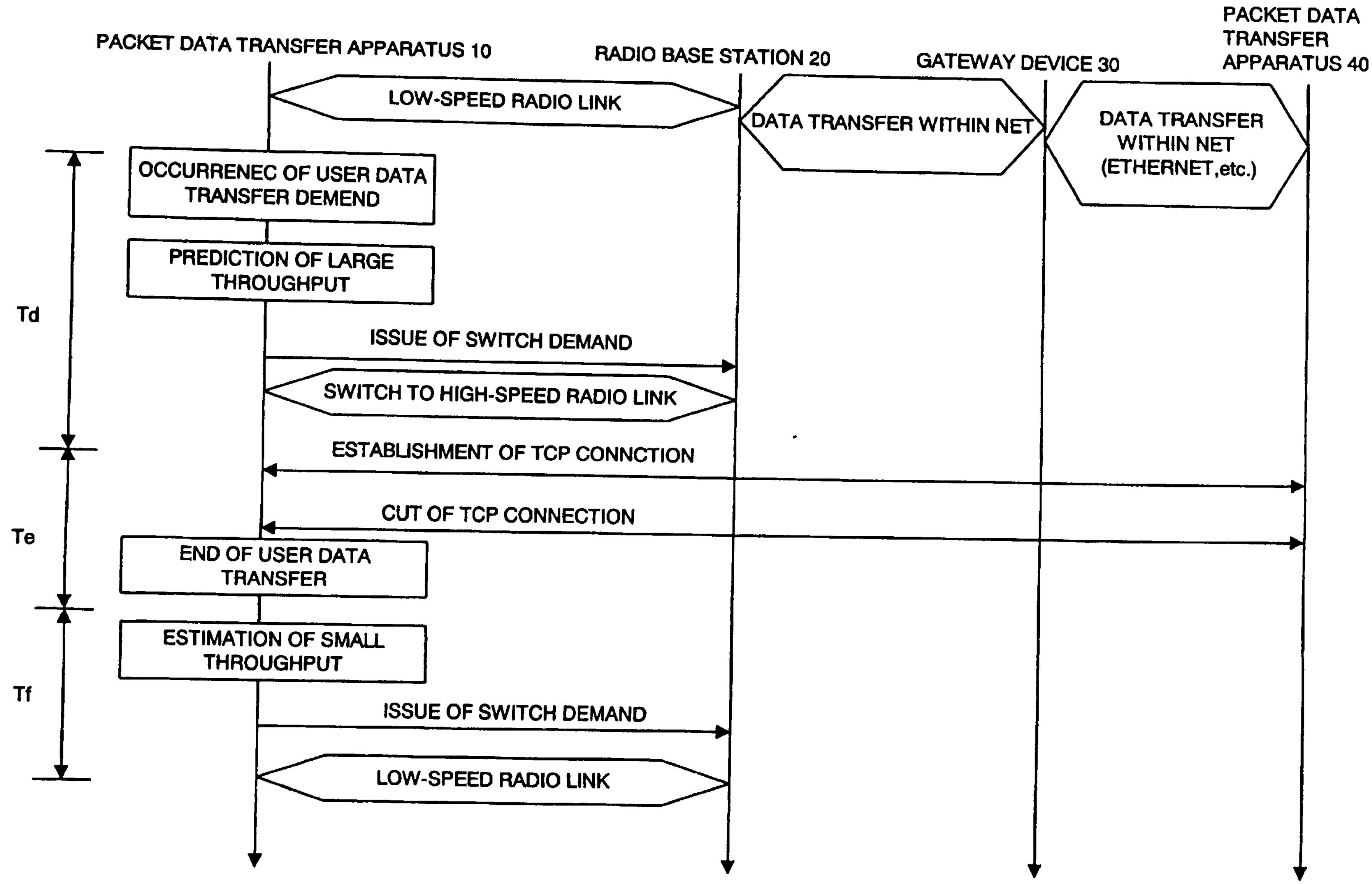

PACKET DATA TRANSFER APPARATUS 10
RADIO BASE STATION 20
GATEWAY DEVICE 30
PACKET DATA TRANSFER APPARATUS 40
LOW-SPEED RADIO LINK
DATA TRANSFER WITHIN NET
DATA TRANSFER WITHIN NET (ETHERNET,etc.)
OCCURRENEC OF USER DATA TRANSFER DEMEND
PREDICTION OF LARGE THROUGHPUT
ISSUE OF SWITCH DEMAND
SWITCH TO HIGH-SPEED RADIO LINK
ESTABLISHMENT OF TCP CONNCTION
CUT OF TCP CONNECTION
END OF USER DATA TRANSFER
ESTIMATION OF SMALL THROUGHPUT
ISSUE OF SWITCH DEMAND
LOW-SPEED RADIO LINK
Td
Te
Tf

FIG. 4

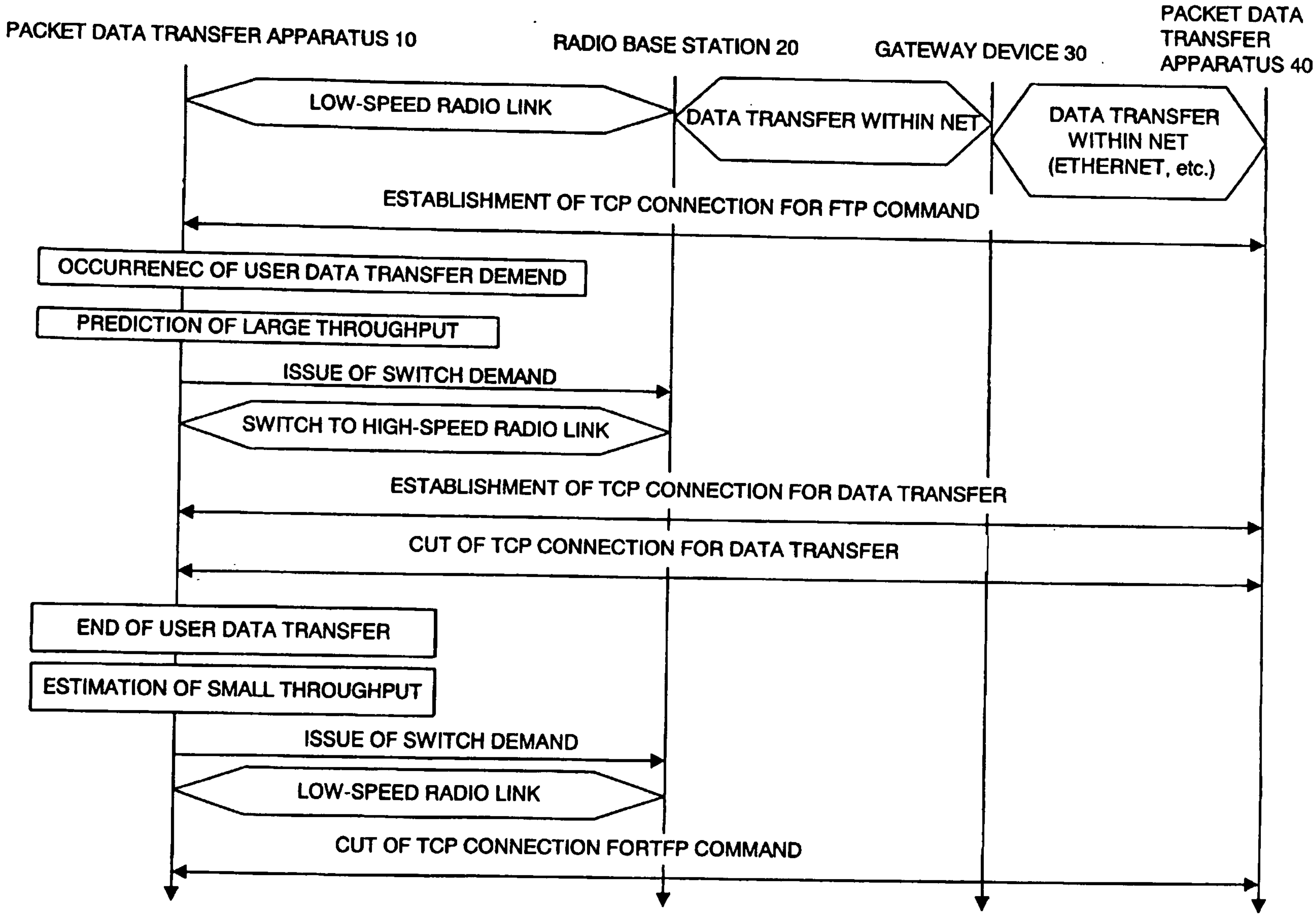

PACKET DATA TRANSFER APPARATUS 10
RADIO BASE STATION 20
GATEWAY DEVICE 30
PACKET DATA TRANSFER APPARATUS 40
LOW-SPEED RADIO LINK
DATA TRANSFER WITHIN NET
DATA TRANSFER WITHIN NET (ETHERNET, etc.)
ESTABLISHMENT OF TCP CONNECTION FOR FTP COMMAND
OCCURRENEC OF USER DATA TRANSFER DEMEND
PREDICTION OF LARGE THROUGHPUT
ISSUE OF SWITCH DEMAND
SWITCH TO HIGH-SPEED RADIO LINK
ESTABLISHMENT OF TCP CONNECTION FOR DATA TRANSFER
CUT OF TCP CONNECTION FOR DATA TRANSFER
END OF USER DATA TRANSFER
ESTIMATION OF SMALL THROUGHPUT
ISSUE OF SWITCH DEMAND
LOW-SPEED RADIO LINK
CUT OF TCP CONNECTION FORTFP COMMAND

FIG. 5

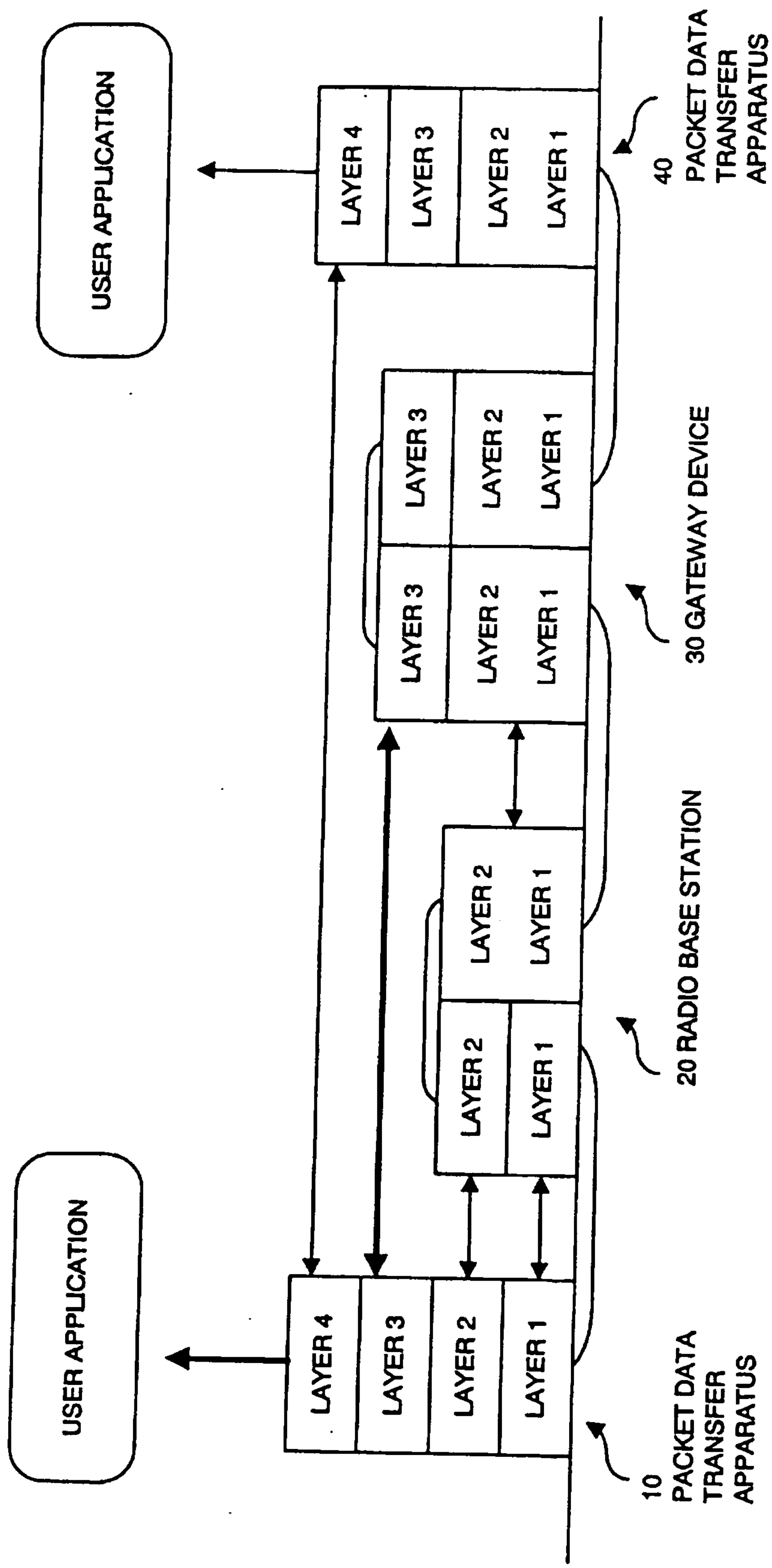

USER APPLICATION
LAYER 4
LAYER 3
LAYER 2
LAYER 1
40 PACKET DATA TRANSFER APPARATUS
LAYER 3
LAYER 2
LAYER 1
LAYER 3
LAYER 2
LAYER 1
30 GATEWAY DEVICE
LAYER 2
LAYER 1
LAYER 2
LAYER 1
20 RADIO BASE STATION
USER APPLICATION
LAYER 4
LAYER 3
LAYER 2
LAYER 1
10 PACKET DATA TRANSFER APPARATUS

FIG. 6
PRIOR ART

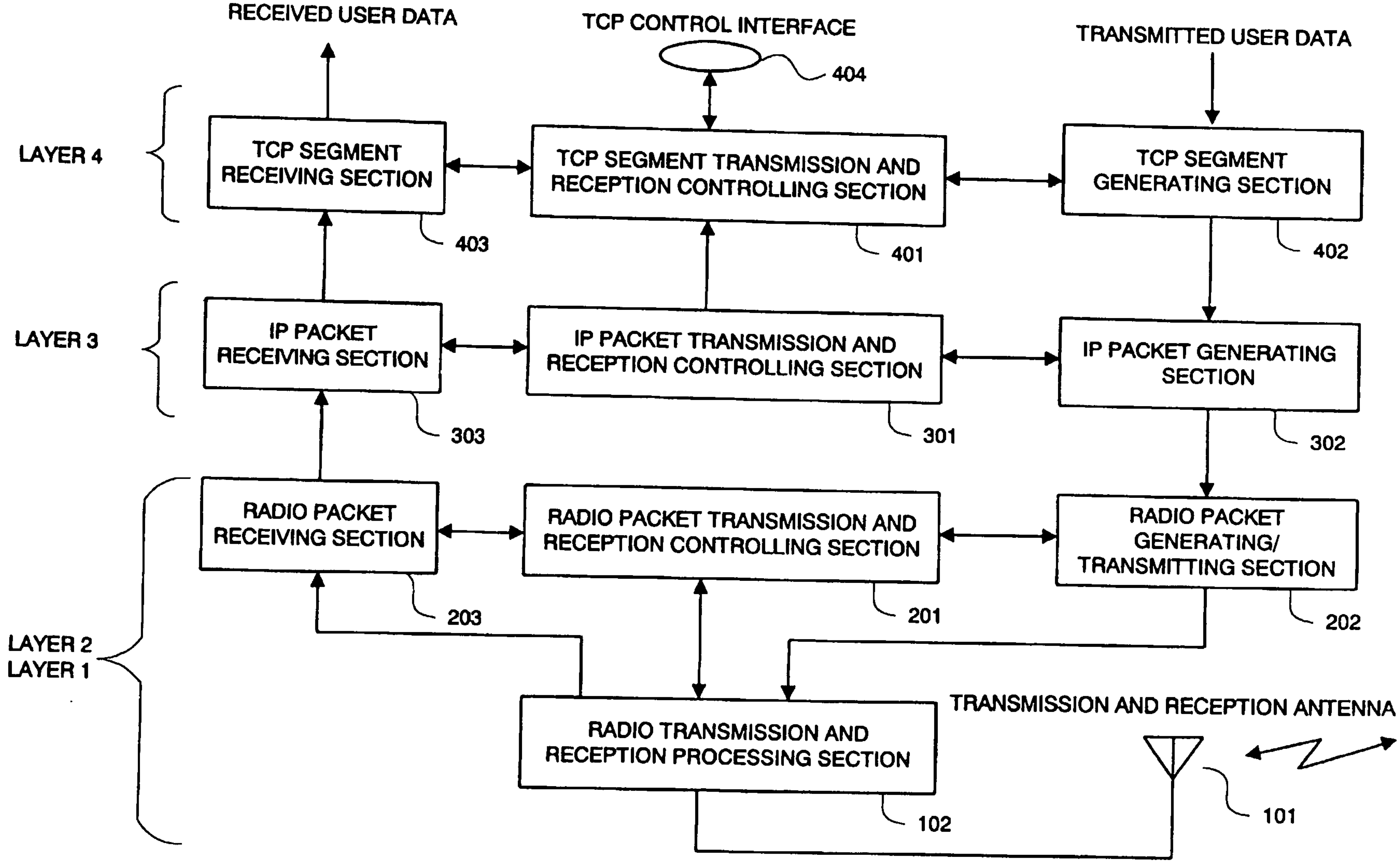


FIG. 7
PRIOR ART

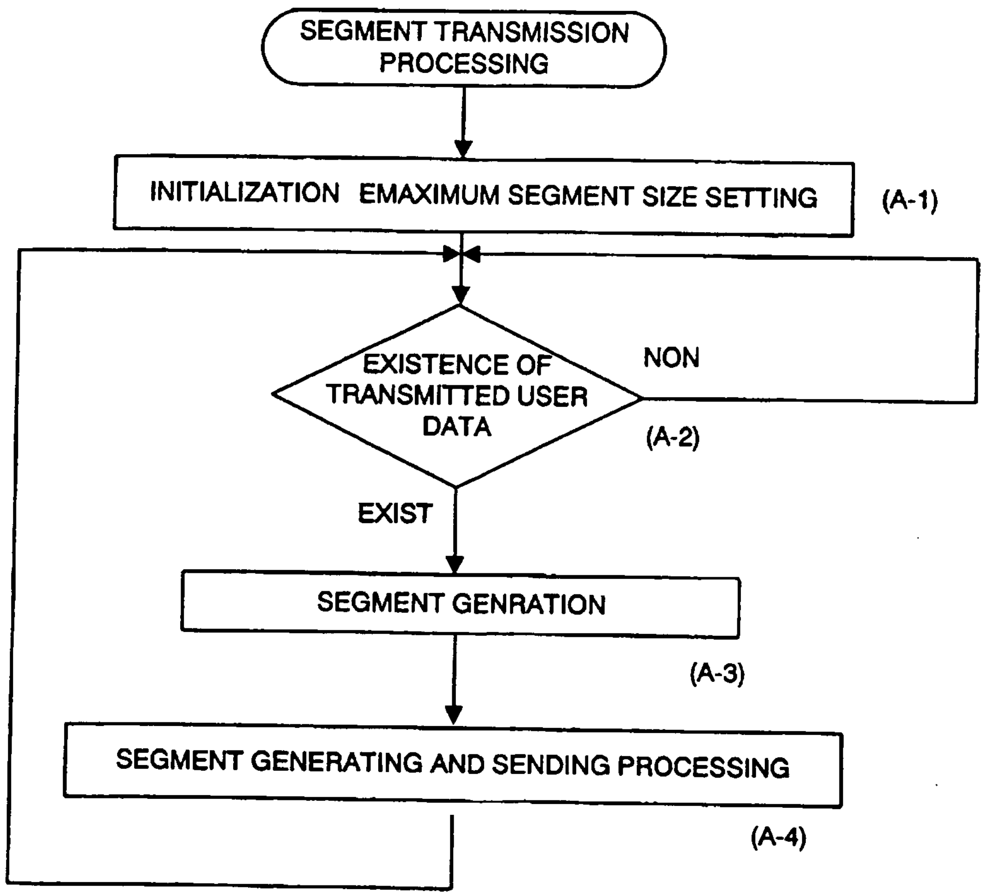


FIG. 8

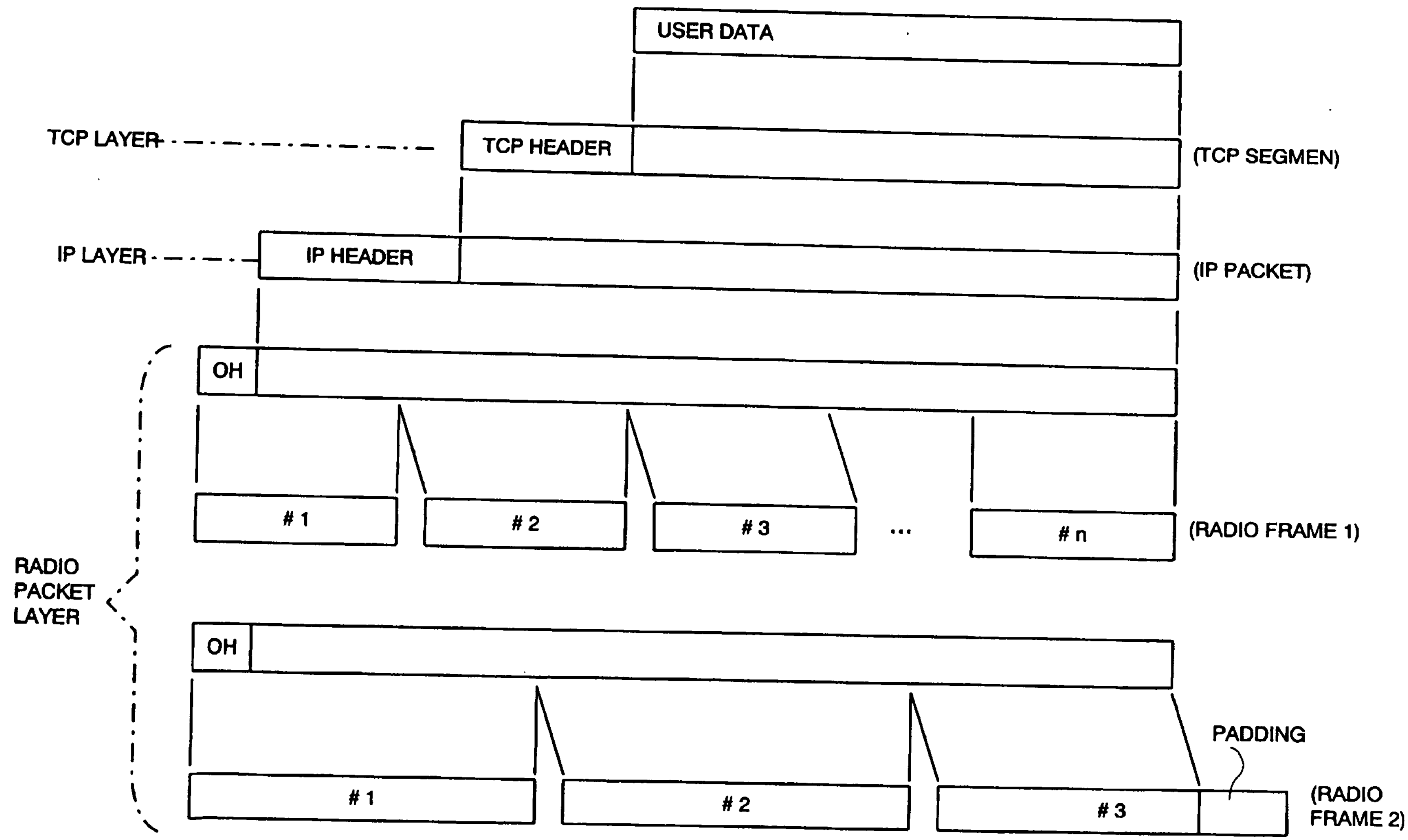
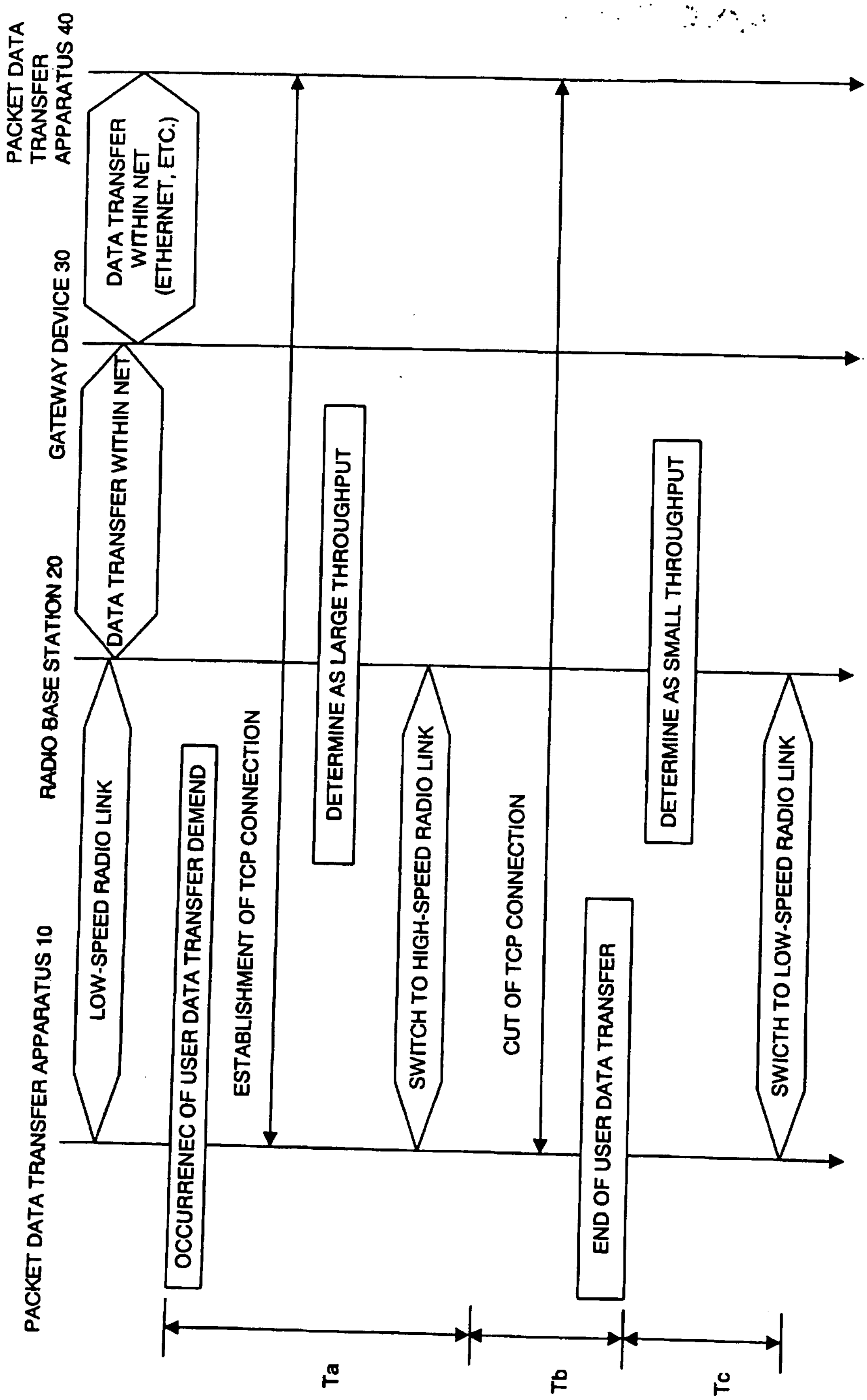

USER DATA
TCP LAYER
TCP HEADER
(TCP SEGMEN)
IP LAYER
IP HEADER
(IP PACKET)
OH
1
2
3
...
n
(RADIO FRAME 1)
RADIO
PACKET
LAYER
OH
PADDING
1
2
3
(RADIO
FRAME 2)

FIG. 9
PRIOR ART



2351874

PACKET DATA TRANSFER APPARATUS

BACKGROUND OF THE INVENTION

The present invention relates to a packet data transfer apparatus for radio packet communication, and especially to a TCP segment size controlling method, and radio packet system control which depends on user data occurrence condition.

In Fig. 5, a protocol stack between two communication terminals that conduct a TCP data transfer on radio packet communication is shown. Here, it is assumed that each layer is taking a share in a function in accordance with an OSI reference model.

A radio link is provided between a packet data transfer apparatus 10 and a radio base station 20, and provides radio packet communication by a layer 2 or lesser layer. A wire link is provided between the radio base station 20 and a gateway device 30, and the layer 2 or lesser layer have unique protocols within a net.

A wire link is provided between the gateway device 30 and a packet data transfer apparatus 40, and the layer 2 or lesser layer have other protocols within a net. A case can be considered in which an ethernet is used.

It is assumed that, in a layer 3, an IP is used between the packet data transfer apparatus 10 and the packet data transfer apparatus 40. It is assumed that, in a layer 4, a TCP is used between the packet data transfer apparatus 10 and the packet data transfer apparatus 40.

A user data to be transferred, which occurs in a user application on the packet data transfer apparatus 10 is shaped into a TCP segment in the TCP (layer 4), is shaped into an IP packet in the IP (layer 3), to which an IP header is added, and is converted into a frame in the layer 2, which is unique to radio packet communication, and thereafter, is sent by means of radio in a layer 1.

The radio frame which was sent by means of radio from the packet data transfer apparatus 10 is received by the radio base station 20, and is transferred to the gateway device 30 by using a unique transfer method in a net protocol.

In the gateway device 30, the IP packet is reconstructed, and the IP packet is transferred through a net such as an ethernet, and is transferred to the packet data transfer apparatus 40.

In the packet data transfer apparatus 40, a user data is taken out from the reconstructed TCP segment, and is delivered to a user application on the packet data transfer apparatus 40.

In Fig. 6, a block diagram of a packet data transfer apparatus for conducting a TCP data transfer at a radio packet by means of the prior art is shown.

A TCP segment generating section 402 receives transmitted user data and generates a TCP segment having a size of which an upper limit is a maximum segment size, and delivers it to an IP packet generating section 302.

The IP packet generating section 302 adds an IP header to the TCP segment which was received from the TCP segment generating section 402, and generates an IP packet, and delivers it to a radio packet generating/transmitting section 202.

The radio packet generating/transmitting section 202 reconstructs the IP packet into a unique frame in radio packet communication, and delivers it to a radio transmission and reception processing section 102.

The radio transmission and reception processing section 102 conducts radio transmission of the transmitted radio frame from the radio packet generating/transmitting section 202 through a transmission and reception antenna 101. Also, the radio transmission and reception processing section 102 takes out a received radio frame from the transmission and reception antenna 101, and delivers it to a radio packet receiving section 203.

The radio packet receiving section 203 reconstructs a

radio packet from the radio frame, and delivers it to an IP packet receiving section 303.

The IP packet receiving section 303 reconstructs the radio packet which was received from the radio packet receiving section 203 into an IP packet, and delivers it to a TCP segment receiving section 403.

The TCP segment receiving section 403 reconstructs a TCP segment from the IP packet, and outputs received user data.

A radio packet transmission and reception controlling section 201 controls the radio packet generating/transmitting section 202 and the radio packet receiving section 203 based on information from the radio transmission and reception processing section 102. Also, the radio packet transmission and reception controlling section 201 conducts control in accordance with a control data addressed to the radio packet transmission and reception controlling section 201, which was received from the radio base station 20, and at the same time, transmits the control data to a radio packet transmission and reception controlling section (not shown) of the radio base station 20.

The transmitted control data from the radio packet transmission and reception controlling section 201 is transmitted and processed from the radio packet

transmission and reception controlling section 201 through the radio packet generating/transmitting section 202 like the user data.

In the same manner, received control data from a radio packet transmission and reception controlling section (not shown) of the radio base station 20 is received and processed in the radio transmission and reception processing section 102 like the user data, and thereafter, is delivered to the radio packet transmission and reception controlling section 201 through the radio packet receiving section 203.

An IP packet transmission and reception controlling section 301 controls the IP packet generating section 302 and the IP packet receiving section 303. Also, the IP packet transmission and reception controlling section 301 notifies a TCP segment transmission and reception controlling section 401 of a maximum size (MTU; Maximum Transport Unit) of an IP packet during initial setting of a data transfer.

The TCP segment transmission and reception controlling section 401 controls the TCP segment generating section 402 and the TCP packet receiving section 403. Also, during a data transfer, the TCP segment transmission and reception controlling section 401 conducts transmission and reception of a control data with a TCP segment

transmission and reception controlling section (not shown) that is other party to communicate with, and controls a confirmation response, resending, transmission and reception rate and so forth of a TCP segment. Further, the TCP segment transmission and reception controlling section 401 exchanges data with a control interface 404 for transferring TCP data to a user application.

In Fig. 7, a flowchart of maximum segment size control of a TCP by means of the prior art is shown.

First, after initialization, a maximum segment size (MSS; Maximum Segment Size) of a TCP is set only one time, when a TCP connection is established (A-1). This is calculated based on the MTU which was notified from the IP packet transmission and reception controlling section 301.

Next, in a case where transmitted user data exists (A-2), a segment is generated (A-3), and segment sending processing is conducted (A-4).

In Fig. 8, a data flow between layers,until user data is divided and processed into a size to be transferred by means of a radio frame,is shown.

User data is delivered to the radio packet generating/ sending section 202 under condition that a TCP header is added thereto in a TCP layer, and an IP header is added thereto in an IP layer. In the radio packet generating/ sending section 202, a unique overhead (shown

as "OH" in Fig. 8) in this layer is added thereto, and it is divided into a radio frame unit.

Here, in a radio frame 1, a radio packet to be transferred is being divided into just n. Although, in a radio frame 2, the radio packet to be transferred is being divided into three, since a data in a high position, which fills up a third radio frame, does not exist, padding of a useless data (a zero value and so forth) is conducted.

In Fig.9, a time line of a TCP data transfer on radio packet communciation by means of the prior art is shown. Between the radio base station 20 and the gateway device 30, and between the gateway device 30 and the packet data transfer apparatus 40, a condition in which a data transfer can be conducted by means of respective unique protocols within a net is established.

For the radio link between the packet data transfer apparatus 10 and the radio base station 20, a low-speed radio link is used when data to be transferred is comparatively less, and a high-speed radio link is used when data to be transferred is comparatively more. With regard to the switch of both high-speed and low-speed, the radio base station 20 monitors throughput of a data transfer, and when it is determined that the throughput is large, switching to the high-speed link is conducted, and when it is determined that the throughput is small,

switching to the low-speed link is conducted. When there is no user data to be transferred, condition of the low-speed radio link is established.

Here, an example in which demand for a transfer of user data occurs in the packet data transfer apparatus 10 is shown.

A connection of a TCP is established under condition of a low-speed radio link. Since a TCP segment for establishment of the connection of the TCP is small, it is determined that the throughput is small.

If, at a time when data transfer demand occurs and a time period Ta has passed, the radio base station 20 determines that the throughput is large, the radio link is set to a high-speed link again. A subsequent data transfer is conducted over a time period Tb in the high-speed radio link, and a cut of the TCP connection is conducted, and a transfer of the user data is finished. After the transfer of the user data is finished and a time period Tc has passed, the radio base station 20 determines that the throughput is small, and the radio link is set to a low-speed radio link again.

A first task is that the maximum segment size is consistently fixed during communication. The reason thereof is that the maximum segment size is set only at the initial setting of an operation.

A second task is that control of the TCP, which is connected with an operation of layers in a subordinate position, cannot be conducted. Also, control of the layers in a subordinate position, which depends on condition of the occurrence of a user data of the TCP, cannot be conducted. The reason thereof is that an interface for an information exchange between the layers in a subordinate position and the TCP does not exist.

SUMMARY OF THE INVENTION

An objective of the preferred embodiments of the present invention is to improve the throughput of a TCP data transfer in radio packet communication. Also, an objective of the preferred embodiments is to realize more efficient utilization of radio resources.

In the present invention, in order to solve the above-described tasks, as first means, an interface for exchanging mutual operation information between the layers in a subordinate position and the TCP is prepared. As second means, when a change occurs in transfer condition of the layers in a subordinate position, in accordance with that, the maximum segment size is also reset to a most suitable one in time. As third means, the maximum segment size in a radio section can be notified, in the

middle of a data transfer, to a TCP for communication with another party. As fourth means, the setting of a transfer condition of the layers in a subordinate position can be changed, dependent on a condition of the occurrence of user data of the TCP.

By means of the above-described first means, the operations shown in relation to the second and fourth means are realized. Thereby, cooperation of the operations of the TCP and the layers in a subordinate position can be realized.

By means of the second means, dynamic TCP segment size control is conducted, for a frame size of the layers in a subordinate position. Accordingly, since a more efficient transfer of user data can be realized, the throughput is improved.

By means of the third means, also with respect to a data transfer from the TCP that is used to communicate with the other party, a data transfer is conducted, in which the most suitable maximum segment size control is conducted in a radio section. Accordingly, since a more efficient transfer of user data can be realized, the throughput is improved.

By means of the fourth means, transfer condition control of the layers in a subordinate position, which is appropriate for a frequency of the occurrence of a user

data of a TCP, is conducted. Accordingly, since a more efficient transfer of the user data can be realized, the throughput is improved, and at the same time, an effective allocation of radio resources can be realized.

A further broad aspect of the invention is as set out in claim 1.

BRIEF DESCRIPTION OF THE DRAWINGS

Preferred features of the present invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Fig. 1 is a constitution block diagram of a radio packet data transfer apparatus of the present invention;

Fig. 2 is a view showing a flowchart of TCP maximum segment size control of the radio packet data transfer apparatus of the present invention;

Fig. 3 is a time line view of a radio packet data transfer of the present invention;

Fig. 4 is a time line view of a radio packet data transfer of another embodiment of the present invention;

Fig. 5 is a protocol stack view of radio packet communication;

Fig. 6 is a constitution block diagram of a conventional radio packet data transfer apparatus;

Fig. 7 is a view showing a flowchart of TCP maximum segment size control of the conventional radio packet data

transfer apparatus;

Fig. 8 is a view of a data flow between layers;and,

Fig. 9 is a time line view of a conventional radio packet data transfer.

DESCRIPTION OF THE EMBODIMENTS

Embodiments of the present invention will be explained in detail by referring to drawings.

In Fig. 1, a block diagram of an embodiment of the present invention is shown.

With regard to elements the same as those in the constitution block diagram of the prior art, which was shown in Fig. 6, the same symbols are attached, and explanation thereof is omitted.

A radio packet control interface 204 discloses information of radio packet transmission and reception processing control to other modules, which is conducted in a radio packet transmission and reception controlling section 201. Also, a service for indirectly controlling radio packet transmission and reception control is provided through this radio packet control interface 204.

An IP packet transmission and reception controlling section 301 acquires a current radio packet transmission size through the radio packet control interface 204, in addition to the functions shown in relation to the prior

art, and controls a maximum size (MTU) of a transmitted IP packet.

A TCP segment transmission and reception controlling section 401 acquires a current radio packet transmission size through the radio packet control interface 204, in addition to the functions shown in relation to the prior art, and controls a maximum size (MSS) of a transmitted TCP segment. Further, the TCP segment transmission and reception controlling section 401 issues a control demand for transmission and reception control of a radio packet through the radio packet control interface 204 in accordance with the contents of a data transfer demand from a user application. Here, the contents of the data transfer demand from the user application can be acquired from a TCP control interface 404 and the contents of transmitted user data.

Next, an operation of this embodiment will be explained. In Fig. 2, a flowchart of a maximum segment size controlling method of a TCP is shown in relation to the operation of the embodiment of the present invention.

First, in a case where transmitted user data exists (B-3), processing is started.

Since a most suitable value of the maximum segment size (MSS) of a TCP changes in accordance with transfer condition at the time of a radio packet, it is determined

whether resetting is necessary every time a transmission demand of a user data occurs (B-2). Information for the determination can be acquired from the radio packet control interface 204 shown in Fig. 1.

If it determined that the resetting is necessary, the maximum segment size is set to a new value (B-3). Regarding maximum segment size, there is one for transmission and one for reception. When a data transfer is conducted in the new maximum segment size for transmission, a segment, in which information of the new maximum segment size for reception is added to a TCP header to be attached to the segment, is generated (B-4), and segment sending processing is conducted (B-5).

By using this control, when a TCP segment having the maximum segment size is sent, a radio frame does not occur in which there is padding like in a case of the radio frame 2, shown in the data flow of Fig. 8.

Next, complete operation of the embodiment of the present invention will be explained by using Fig. 3.

An example of an operation, in which a transfer demand of user data occurs in the packet data transfer apparatus 10 shown in Fig.5, will be shown.

A case in which user data transfer demand occurs during condition of a low-speed radio link will be

explained. When a data transfer having large throughput is predicted through the TCP control interface 404 of Fig. 1 or from the contents of transmitted user data, the packet data transfer apparatus 10 issues a demand to the radio base station 20 so as to switch the low-speed radio link to a high-speed radio link before establishment of a TCP connection. In accordance with that, the radio base station 20 conducts switching to the high-speed radio link. A time period from the issue of the user data transfer demand to the switching to the high-speed link is Td.

The packet data transfer apparatus 10 conducts data transfer processing from the establishment of a TCP connection when it is switched to the high-speed link, and cuts the TCP connection when a transfer of data to be transferred is finished. A time period required for the data transfer is Te.

When the user data transfer is finished, throughput after that apparently becomes small (zero). Accordingly, the packet data transfer apparatus 10 immediately issues a switch demand from the high-speed radio link to a low-speed radio link, and switches the radio link to low-speed one. A time period required for this processing is Tf.

By means of the embodiment of the present invention, which was shown above, the data transfer throughput is

improved.

This is because, since the most suitable TCP maximum segment size is used in accordance with transfer condition of a radio packet having a low-speed link or a high-speed link, useless padding does not occur in a radio frame.

Also, that is because, since the TCP data transfer processing is not conducted in the low-speed link and is conducted only in the high-speed link, a sum total of a transfer time period is shortened.

Also, by means of the embodiment of the present invention, effective utilization of radio resources is facilitated.

This is because, since a time period for switching to the low-speed radio link after the user data transfer is shortened, radio resources for the high-speed link are not wasted.

Furthermore, by means of the embodiment of the present invention, timer control of the TCP is conducted more appropriately, and a drop of the throughput and an addition thereof to a network due to occurrence of unnecessary resending of a TCP segment, and so forth can be reduced.

This is because, since conventionally a TCP data transfer is conducted in both of the low-speed link and the high-speed link, reliability of round trip time

measured by obtaining a confirmation response of a TCP is low, however, since a link having the same speed is maintained during a data transfer, reliability of the round trip time is improved.

In radio packet communication in IMT-2000, a competitive system in which the same radio channel is shared with other radio mobile stations is used when data throughput is comparatively small, and a reservation system in which individual radio channels are allocated for every radio mobile station is used when data throughput is comparatively large.

In other words, these correspond to the radio low-speed link and the radio high-speed link which were shown in the embodiment. Accordingly, the present invention can be applied to a packet communication service of the IMT-2000 as it is.

With regard to an arrangement, it is the same as Fig. 1 shown in the embodiment. Here, each functional block of the IMT-2000 is allocated to radio packet layers shown as the layer 1 and the layer 2 that were shown in Fig. 1.

Next, an operation of the embodiment will be explained.

In this embodiment, a case will be explained in which a user application on the packet data transfer apparatus 40 of Fig. 5 is a Web browser, and a user application on the packet data transfer apparatus 10 is a Web browser.

For a figure for the explanation of an operation, a time line view of Fig. 3 is used. Here, it is assumed that the packet data transfer apparatus 10 is a mobile station.

Initially, the mobile station is under condition in which it competitively utilizes a radio channel that is common to other mobile stations. In a case where the mobile station designates a certain specific URL by means of the Web browser, and conducts a transfer of an HTML file, since the mobile station can predict that a transfer of a user data having large throughput occurs by observing that an initial transmitted user data starts from "GET /", the mobile station immediately issues a demand of individual radio channels of a reservation system.

The radio base station 20 receives this, and if there is a margin in radio resources, the individual radio channels are allocated, and a condition in which a high-speed data transfer can be realized is established. At this time, a maximum segment size appropriate for the individual radio channels when a TCP connection is established is also notified. Thereafter, down-load of the HTML file is conducted.

Next, in case of using an FTP for a user application, its time line is shown in Fig. 4.

In this case, a user application on the packet data transfer apparatus 40 shown in Fig. 5 is an FTP server,

and a user application on the packet data transfer apparatus 10 is an FTP client.

Initially, the mobile station is under condition in which it competitively utilizes a radio channel that is common to other mobile stations. When the FTP client has access to the FTP server, initially a TCP connection for an FTP command is set. At this time, a maximum segment size is set to a most suitable value because of a competitive system.

In a case where transmitted user data is an FTP command which starts from "get", "put", and so forth, the mobile station predicts that a transfer demand a user data having large throughput occurs, and immediately issues a demand of individual radio channels of a reservation system.

The radio base station 20 receives this demand, and if there is a margin in radio resources, the individual radio channels are allocated, and a condition in which a high-speed data transfer can be realized is established. When a TCP connection for a data transfer is established, a maximum segment size appropriate for the individual radio channels is set.

Thereafter, transfer processing of a file is conducted. The file transfer is finished, and when the TCP connection for a data transfer is cut, since it is predicted that

condition of the user data transfer is moved to a small throughput, the mobile station issues a demand for the switching to a radio link and a competitive system. The radio base station 20 receives this demand, and switching to a radio channel which is competitively utilized by other mobile channels is conducted.

A first advantage is that TCP data transfer throughput is improved.

The reason thereof is that, since a TCP segment is generated with a maximum segment size which is most suitable at that time in accordance with transfer condition of a radio packet, useless padding does not occur in a step in which a radio frame is constructed.

Also, since, by predicting large throughput of user data before a start of a data transfer and conducting data transfer under a condition of a high-speed link, a data transfer in a low-speed link due to a detection delay of a throughput level by means of the conventional radio base station is eliminated, a sum total transfer processing time period is shortened.

A second advantage is that a most suitable allocation of radio resources can be realized.

The reason thereof is that, by predicting a small throughput of user data after data transfer is finished and conducting the switching to the low-speed

link, it is possible to avoid a useless occupation of radio resources for the high-speed link due to a detection delay of a throughput level by means of the conventional radio base station.

A third advantage is that timer control of a TCP is conducted appropriately, and resending of an unnecessary TCP segment does not occur.

The reason thereof is that, since the radio link speed is maintained constant during a TCP data transfer, mismatch of the timer control, which occurs in a case where data transfer processing is conducted in the low-speed link and the high-speed link as in the conventional manner, does not occur.

While the present invention has been described in its preferred embodiments, it is to be understood that the words which have been used are words of description rather than limitation, and that changes may be made to the invention without departing from its scope as defined by the appended claims.

The text of the abstract filed herewith is repeated here as part of the specification.

For information acquisition and control of a radio packet transmission and reception controlling section, a radio packet control interface is prepared, and based on radio channel information obtained through this interface, an IP packet transmission and reception controlling section dynamically controls a maximum packet size, and a

TCP segment transmission and reception controlling section dynamically controls a maximum segment size, and issues a radio channel control demand to a radio packet transmission and reception controlling section in accordance with a transfer demand condition of user data in at a high level, which is obtained through a TCP control interface.

CLAIMS:

1. A packet data transfer apparatus comprising:

a TCP segment layer, having TCP segment transmitting and receiving sections and a TCP segment controller for controlling those sections;

an IP packet layer, having IP packet transmitting and receiving sections and an IP packet controller for controlling those sections;

a radio packet layer, having radio packet transmitting and receiving sections and a radio packet controller for controlling those sections; and,

a radio transmission/reception processing section layer;

wherein said radio packet controller of the radio packet layer has a radio packet control interface for allowing other layers to acquire radio packet layer information and for requiring said radio packet controller to exercise radio packet layer control.

2. A packet data transfer apparatus having first, second, third and fourth layers, the apparatus comprising:

a fourth-layer segment generating section for dividing transmission transfer data into lengths equal to or less than a predetermined size, adding a fourth-layer protocol header, and generating a fourth-layer segment;

a third-layer packet generating section for adding a

third-layer protocol header to said fourth-layer segment and generating a third-layer packet;

a second-layer packet generating/sending section for adding a header or a trailer of a second-layer protocol to said third-layer packet and generating a second-layer packet;

a first-layer transmission and reception processing section for applying a first-layer protocol process to said second-layer packet, and transferring it to a data transfer device of a communicating other party, and alternatively, for applying the first-layer protocol process to reception data from a packet data transfer device of the communicating other party and for reconstructing the second-layer packet;

a second-layer packet receiving section for removing a second-layer header or trailer from said reconstructed second-layer packet and for reconstructing the third-layer packet;

a third-layer packet receiving section for removing a third-layer header from said reconstructed third-layer packet and for reconstructing the fourth-layer segment;

a fourth-layer segment receiving section for removing a fourth-layer header from said reconstructed fourth-layer segment and for outputting reception transfer data;

a fourth-layer segment transmission and reception controlling section for controlling said fourth-layer segment generating section and said fourth-layer segment

receiving section;

a third-layer packet transmission and reception controlling section for controlling said third-layer packet generating section and said third-layer packet receiving section; and,

a second-layer packet transmission and reception controlling section for controlling said second-layer packet generating/sending section and said second-layer packet receiving section;

wherein said fourth-layer segment transmission and reception controlling section conducts communication of fourth-layer control data with a fourth-layer segment transmission and reception controlling section of the data transfer device of the communicating other party, through a process that is the same as that for said transmission transfer data;

wherein said third-layer packet transmission and reception controlling section conducts communication of third-layer control data with a third-layer packet transmission and reception controlling section of the data transfer device that communicates with the other party, through a process that is the same as that for the transmission transfer data; and,

wherein said second-layer packet transmission and reception controlling section has a second-layer packet control interface for allowing other layers to acquire second-layer information or for requiring said second-layer

packet transmission and reception controlling section to exercise second-layer control.

3. A packet data transfer apparatus according to claim 2, wherein said fourth-layer segment transmission and reception controlling section comprises means for controlling a maximum size of the fourth-layer segment based on the second-layer information acquired through said second-layer packet control interface, and said third-layer packet transmission and reception controlling section comprising means for controlling a maximum size of the third-layer packet based on the second-layer information acquired through said second-layer packet control interface.

4. A packet data transfer apparatus according to claim 2, wherein said third-layer packet transmission and reception controlling section and said fourth-layer segment transmission and reception controlling section comprising means for acquiring updated second-layer information through said second-layer packet control interface even during a data transfer process, and dynamically controlling a maximum packet size and a maximum segment size, respectively.

5. A packet data transfer apparatus according to claim 2, wherein said fourth-layer segment transmission and

reception controlling section comprises means for predicting a condition of a data transfer which occurs just after a data transfer demand from a user application, and issuing a second-layer packet transfer control demand to said second-layer packet transmission and reception controlling section through said second-layer packet control interface.

6. A packet data transfer apparatus according to claim 5, wherein said second-layer packet transmission and reception controlling comprises means for receiving a second-layer packet transfer control demand from said fourth-layer segment transmission and reception controlling section, and communicating the second-layer packet transfer control demand to a second-layer packet transmission and reception controlling section on a network.

7. A packet data transfer apparatus according to claim 2, wherein a second-layer packet transfer is conducted in said second layer in a high-speed mode when throughput of data to be transmitted and received is large, and is conducted in said second layer in a low-speed mode when throughput of data to be transmitted and received is small.

8. A packet data transfer apparatus according to claim 2, wherein said third layer is an IP packet transmitting

and receiving layer, and wherein said fourth layer is a TCP transmitting and receiving layer.

9. A packet data transfer apparatus substantially as herein described with reference to and as shown in Figures 1 to 8 of the accompanying drawings.

This Page is Inserted by IFW Indexing and Scanning Operations and is not part of the Official Record

BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

- ☐ BLACK BORDERS
- ☐ IMAGE CUT OFF AT TOP, BOTTOM OR SIDES
- ☐ FADED TEXT OR DRAWING
- ☑ BLURRED OR ILLEGIBLE TEXT OR DRAWING
- ☐ SKEWED/SLANTED IMAGES
- ☐ COLOR OR BLACK AND WHITE PHOTOGRAPHS
- ☐ GRAY SCALE DOCUMENTS
- ☑ LINES OR MARKS ON ORIGINAL DOCUMENT
- ☐ REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY
- ☐ OTHER: ______

IMAGES ARE BEST AVAILABLE COPY.
As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.